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ABSTRACT

This book on conservation abilities is part of a series designed to assist beginning and experienced teachers in becoming regular evaluators of their own instruction. The book consists of two parts. The first part provides information on: conservation related to number, length, solid amount, liquid amount, discontinuous length, area, weight, solid volume, and displacement. The second and far longer part consists of 10 self-directed and self-instructive workshops. The goals of these workshops are to: (1) use an assessment method to administer, at any grade level, diagnostic tasks to ascertain conservation abilities; (2) identify the developmental level attained by each student in terms of conservation abilities; and (3) select, from resources available, subject matter (content and manipulative materials) appropriate to the identified levels of development in students' conservation abilities. Except for the first workshop, the order in which workshops are completed or the number completed are at the discretion of the teacher. A short review of some research on conservation abilities, a bibliography, and sample forms used to record students' conservation abilities are included. (JN)

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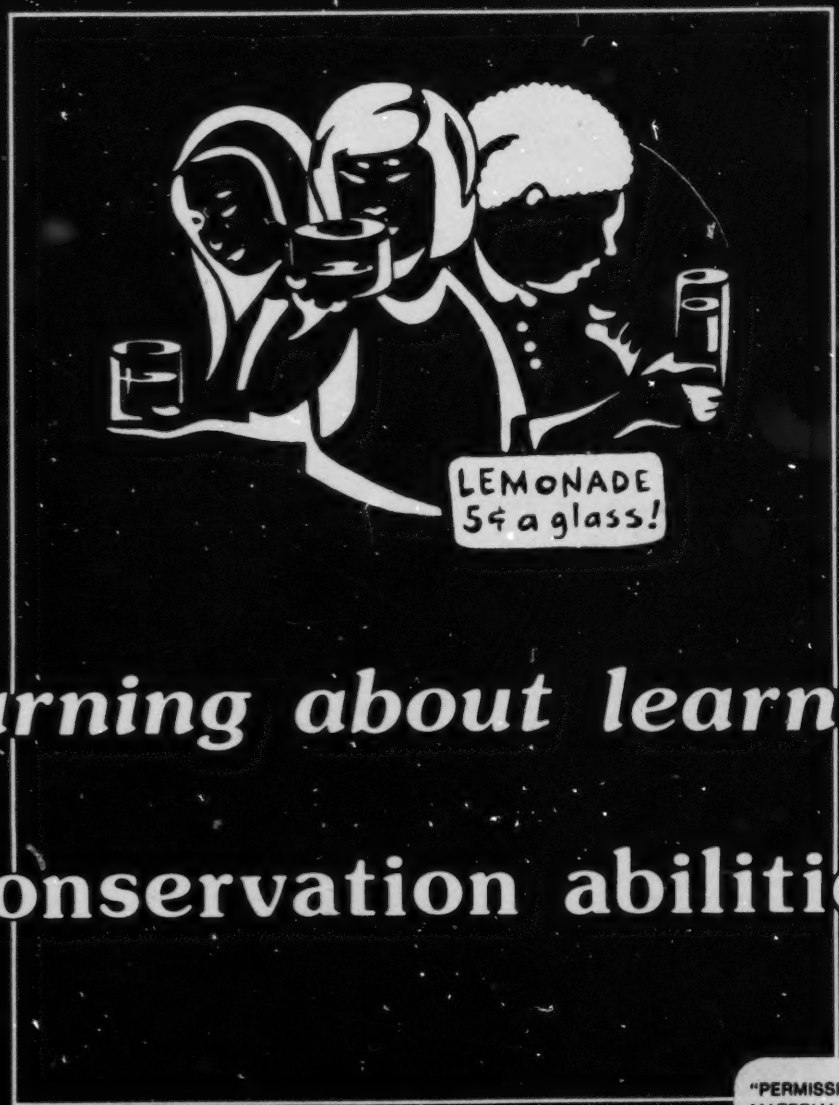

Learning about learning:

Conservation abilities

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LEARNING ABOUT...SERIES

Series developed by

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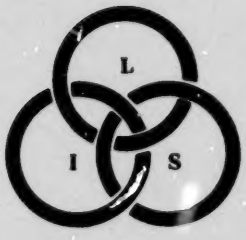

The mission of the Professional Development and Applied Research Center (PDARC) is to explore the components which contribute to learning at all levels—early childhood to adult. There are three components: The **Learner** (L), **Instruction** (I), and **Subject Areas** (S). Research and application in these interrelated areas can promote, for the teacher, a comprehensive approach to daily classroom situations and educational problems. The interwoven rings link the relationships of the themes in such a way that if any one ring is broken, the entire concept falls apart.

learning about learning:

conservation abilities

A PERSONAL WORKSHOP

by

Lawrence F.Lowery

This workshop focuses upon the identification of a set of abilities related to learning. The set, described as conservation abilities, is not independent of but is distinct from other sets of abilities described in other books in the "*Learning about...Series.*" Although you will learn many ideas and develop various skills from experiencing this workshop, three major goals are identified below.

As a result of this workshop, you will be able to:

1. use an assessment method to administer, at any grade level, diagnostic tasks related to conservation abilities;
2. identify the developmental level each student in your class has attained in terms of conservation abilities;
3. select, from resources available, subject matter (content and manipulative materials) appropriate to identified levels of development.

Hopefully you will become able to determine levels of development by observing students during their normal activities without relying upon the administration of the tasks.

This workshop is self-directed and self-instructive. It utilizes written materials, manipulative materials, videotapes, and students in your classroom. It suggests ideas for teaching experiences, record-keeping systems and discussions with colleagues. The value of this and other books in the series depends upon the use of the presented ideas in instructional situations.

This book on Conservation Abilities, developed by the Educational Research and Applications Program, is one of several under the general heading "*Learning About...Series.*" The major objective of this series is to assist beginning and experienced teachers in becoming regular evaluators of their own instruction. Users of this series are taught to use materials and techniques that help assess stages of intellectual development, and to use techniques for assessing their interactions with students.

Many individuals contributed to the content and the field testing of this book. Others checked for detail and accuracy. Without their assistance and expertise, this book could not have been developed.

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Table of Contents

Introduction i

Conservation Tasks

Number 1
Length 3
Solid Amount 5
Liquid Amount 7
Discontinuous Length 9
Area 11
Weight 13
Solid Volume 15
Displacement 17

Self-Directed Workshops

Refining the ability to administer conservation tasks 22
Practicing the administration of the assessment method 27
Assessing the administration of conservation tasks 30
Administering conservation tasks at different levels of development 31
Administering conservation tasks to students 32
Administering conservation tasks to a student 34
Identifying cognitive operations related to conservation abilities 35
Observing the administration of conservation tasks 37
Reading about conservation abilities 38
Thinking through problems involving conservation abilities 45

Review of Research 49

Bibliography 57

Appendix 61

INTRODUCTION

Careful researchers and general observers have well substantiated the idea that fundamental aspects of human learning progress along a continuum that gradually enables individuals to cope more effectively and flexibly with situations and events within their environments. Along this continuum there are levels or way stations in which particular sets of abilities and behaviors are dominant. The characteristics of the behaviors at these way stations are so well defined that each is referred to as a stage of development. The progression along this continuum and through the identified patterns of stages is a universal and invariant process that can be observed in natural, untutored settings. The patterns are the same for all individuals whether they are raised within a primitive culture or a culture of advanced technology.

The biological basis underlying stages along the continuum is established by periodic increases in brain size (Epstein 1974), brain weight (Epstein 1974), cellular growth within the brain (Winick and Rosso 1969), electrical functioning within the brain (Monnier 1960), and head circumference (Eichorn and Bayley 1962). The psychological basis for the stages is established through evidence of the individual's capacity to deal with independent ideas and to relate the ideas in increasing combinations in two-year spurts from about age three through 17 (Pascual-Leone 1970, Case 1974) and the individual's tendency to give the same kinds of incorrect views of the world as other individuals within two- to three-year ranges and as they grow older replace each view by a more sophisticated view which, in turn, is replaced (Piaget 1969). Although different researchers have provided various descriptions of the stage phenomenon (Bruner 1964, Erikson 1950, Gagné 1970, Vygotsky 1974), the person most noted for carefully describing the sequence in terms of periods and stages is Jean Piaget, the Swiss psychologist. His work set a descriptive foundation and vocabulary that enables educators and psychologists to identify, discuss, explore, and perhaps apply information about the stages.

It is not the purpose of this book to present the theoretical ideas of Piaget. These ideas are spread over more than 30 volumes and many articles. It is hoped that the reader will turn to some of the original works to better appreciate and evaluate the spirit of Piaget's enterprise, the nature of his evidence, and the validity of his conclusions.

The Concept of Stages

The term *stage* has been used in the literature without much consistency in definition. In this and other books in the *Learning about...Series,* the term is reserved for qualitatively defined strands of abilities developing through progressive interrelationships. One strand deals with classification abilities. Others deal with seriation abilities, conservation abilities, and propositional reasoning. Conceptual links along any one of these strands allow each stage to be described as a set of behaviors sharing some common feature. As such, a stage is a construct within a structurally defined system upon which there is a unification of a specific set of abilities.

Sequential progression alone is not sufficient for a definition of stages. A definition must include the patterning of responses throughout the sequence. The findings of Shirley (1931) represent an invariant sequence—the behaviors characteristic of the development of locomotion in infancy. However, the components of the sequence are essentially a set of discrete points which bear no clear structural relationship from one to another. Sitting up, for example, does not necessarily have a relationship to holding a hand. Although the sequence is invariant, thus predictable, its components are not stages since there is no structural relationship among them. A definition must include the patterning of responses throughout the sequence.

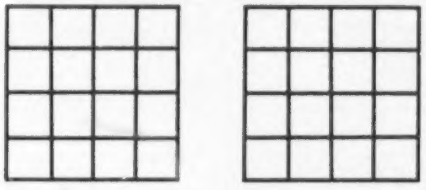
Stages in this book involve sequentiality, a hierarchical integration of lower into higher levels, gradual consolidation in formation, and a structural whole character (unifying interrelated behaviors, concepts, or skills) that results in a broad structural network of interrelated abilities appearing, not all at once, but within a narrowly delimited period with further progress along any strand being deferred until the consolidation of this network.

> Although at any stage of development, nature is preparing us for the next stage, the beauty of the system is that we are conscious of none of this. Ideally, we must fully accept and exist within our developmental stage and respond fully to its content and possibilities. This means that every stage is complete and perfect within itself. The three-year-old is not an incomplete five-year-old; the child is not an incomplete adult. Never are we simply on our way; always we have arrived. Everything is preparatory to something else that is in formation.
>
> Pierce 1977

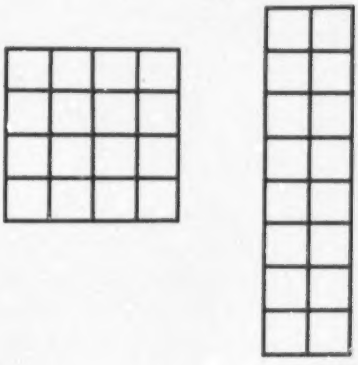
Stages in the Conservation Abilities Strand

The term *conservation* is used to describe the achievement of a particular set of cognitive operations. These operations are revealed when a student grasps the notion that something remains the same (is conserved) even though it may be rearranged or transformed in some way and therefore appear to be different. For example, if after taking two identical sets of 16 one-inch squares and arranging each set to form two identical larger squares (a), a student judges the surfaces they cover to be equal in area, observes as you rearrange one square into another pattern (b), and states that the amount of surface covered by the squares is still the same, then one can say that the student has indicated an ability to *conserve area.* If, on the other hand, the student states that the rearranged squares now cover a greater or lesser area, one can say that the student did not conserve area.

a.



b.



The student who conserves can reverse a rearrangement or transformation in his mind. The capability of being able to reverse one's thinking (reversibility) is a major achievement in cognitive development. To Piaget, there are two cognitive operations that are evidences of reversibility:

1. *Negation (Inversion) Operation*—the ability to retrace changes (transformations) back to their logical beginnings.

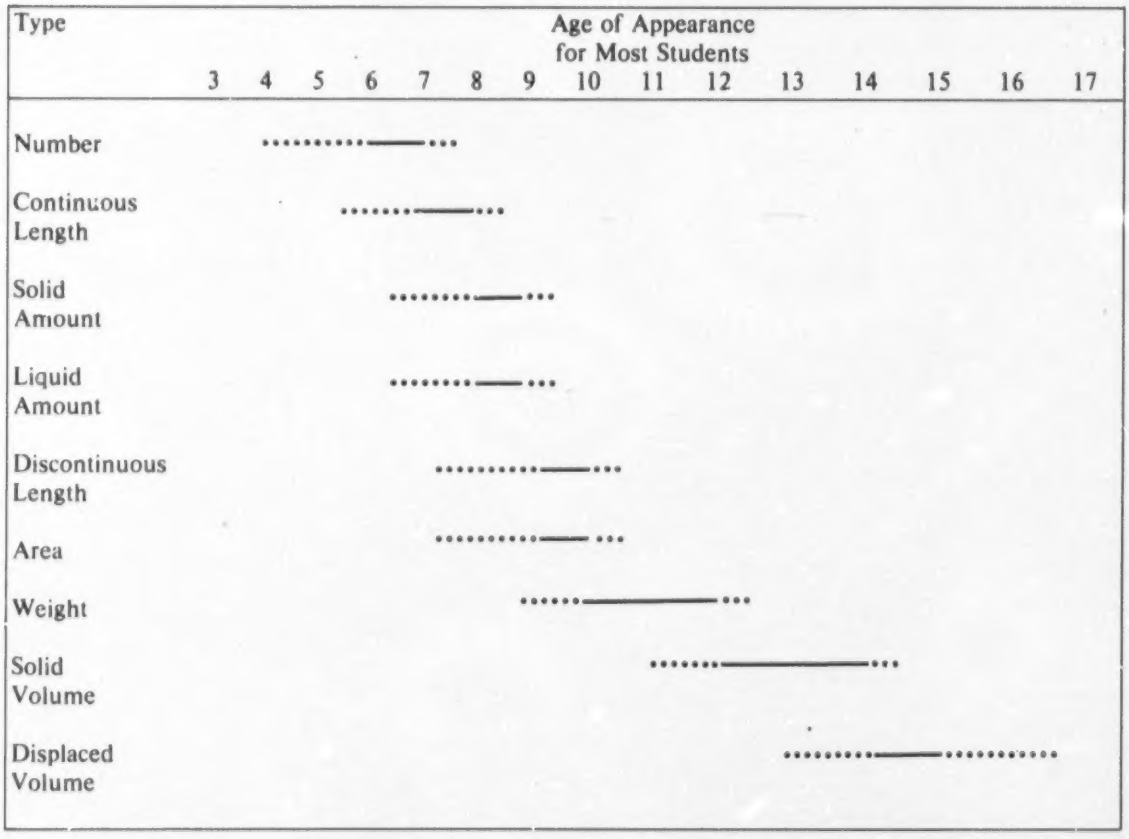
   In the example given, the student who can conserve area is one who can mentally reconstruct how the area appeared before it was rearranged. When asked why he feels the areas are equal, the student might say, "*Because you can put the squares back the way they were before.*" For this student the physical operation of rearranging the squares (b) can be negated (or inverted) by simply arranging them as they were. This is reversibility by inversion. The student who cannot conserve area is one who cannot invert the transformation in his mind.

2. *Compensation (Reciprocity) Operation*—the ability to relate simultaneously two or more different property changes (transformations), suggesting incompatible results, by a single change that eliminates the apparent conflict.

   In the example given, the student who cannot conserve is one who focuses upon one property in the situation without regard to the others. He might focus upon the property of length in the arrangement of squares (b) without regard to the property of width. He might state, "*You have covered more because it is longer.*" The student who can conserve is one who realizes that any increase in length in one set of squares is compensated for by a reduction in width in the other set of squares. This is reversibility by reciprocal relationship.

Piaget's descriptions of the ways by which students respond to situations involving conservation problems has been verified by various researchers. Different types of conservation such as number, area, and volume are not acquired all at once, and although there can be variations in the age at which individuals achieve each type, the sequence of appearance for many of the types remains unchanged.

Types of Conservation Abilities
Sequence of Appearances



Summary

The student's ability to conserve (to recognize sameness in spite of rearrangements or transformations) is a significant landmark in intellectual development. Prior to this achievement, the student reasons from one particular instance to another particular instance and cannot reverse the process. Thoughts tend to be dominated by perceptions as indicated by focusing upon one property or relationship in a situation to the exclusion of others. As conservation is attained, thoughts become more conceptual. Individuals are then less likely to be taken in by the appearance of things and they can deal with complex relationships, not only taking into account the immediate situation, but mentally making comparisons and exploring similarities and differences in previous experiences.

conservation tasks

With a friend, take turns trying each
of the conservation ability
tasks in this section.

At first, try to use the
suggested dialogue
that accompanies each task,
then gradually incorporate
your own style.

Principle

The number of objects in a set remains the same no matter how the set is rearranged in space (e.g., The number of marbles spread out in a chalk tray will not change when the marbles are placed together in a cup). Most students attain this ability by age six or seven (Beard 1963; Dodwell 1960; Isaacs 1960; Piaget and Szeminska 1952; Wallech, Wall, and Anderson 1967; Wohlwill and Lowe 1962).

Materials

8 white poker chips.
12 matching red chips in a box.

Alternative Materials

Checkers, blocks, jacks, etc.

Task

The student (S) is sitting opposite or alongside the experimenter (E).

E places eight white poker chips in a row in front of S (Since fewer than five chips can be judged by S on a purely perceptual basis, eight is a reasonable minimum to test for conceptually based conservation).

Establishing Initial Equivalence

E: "*Take enough red chips from the box to place one beside each white chip.*"

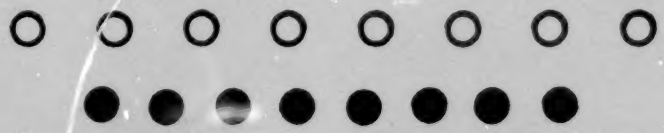
After S matches the chips, E asks: "*How do the red chips compare to the white chips? Are there more red chips or more white chips?*"

If S does not agree upon equivalence, E asks S to make them the same. If S cannot do so, then E discontinues the task.

If S agrees upon equivalence, E continues with the following procedure.

Procedure

E asks S to watch closely while E rearranges the one-to-one correspondence by placing the white chips in a line parallel to the line of red chips but with about twice the spacing between them. The red chips are left untouched for comparative purposes.



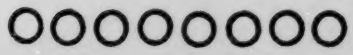
E: "*Now are there more red chips or more white chips?*"

After S's response, E asks for justification: "*How do you know?*" "*How could you be*

sure?" or *"Is there something you can do to prove your idea to me?"*

Regardless of how S responds, E next re-establishes equivalence between the chips, then reduces the spacing between the white chips (a) or collects the white chips into a small group (b). E repeats the previous questions.

a.



b.

Checking Procedure

E: *"Let's pretend that these* (pointing to the red chips) *are candy wrapped in red paper and that these* (pointing to the white chips) *are candy wrapped in white paper. Which would you rather have?"*

After S responds, E asks:
"Why?"

Alternative Procedures

Sometimes S will judge the row acted upon as more numerous regardless of the tranformation. To avoid this judgment, E might act upon both rows.

It is interesting to offer counter suggestions to S (e.g., To a nonconserver who indicated longer row length say: *"Another student said there was still the same amount because I didn't add any."* If S changes to a conservation judgment, repeat the task in a different way, say (b) above, just to check).

S's interest will heighten if candies such as M and Ms are used (Be sure the colors are the same in each row).

Analysis

When S is asked which row contains more objects and replies with a statement that they are the same and gives a satisfactory explanation (e.g., *"You just spaced them out."),* you can feel assured that S is conserving the invariance of number. A shift in judgments indicates S may be in a transitional stage. If S consistently states that the amount is unequal after each transformation, S is a non-conserver.

Length

Principle

The length of an object or line remains the same no matter how it is displaced in space (e.g., A straight wire bent into a circle, remains the same length). Most students attain this ability by age seven or eight (Beard 1963; Lovell, Healey and Rowland 1962; Murray 1968; Smedslund 1963).

Materials

2 identical ice cream sticks (Color coding the materials will aid in avoiding ambiguous descriptions such as: *"That one is longer").*

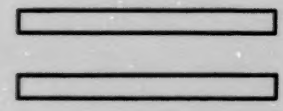
Alternative Materials

Identical pairs of wooden dowels, strips of tagboard, straws, or pipe cleaners.

Task

The student (S) is sitting opposite or alongside the experimenter (E).

E sets the two sticks parallel with both ends even. They will look like this:



Establishing Initial Equivalence

E: *"Are the sticks the same length or is one longer and one shorter?"*

S can manipulate the sticks until satisfied they are equal. If equivalence is not established, discontinue the task.

If S agrees upon equivalence, E continues with the following procedure.

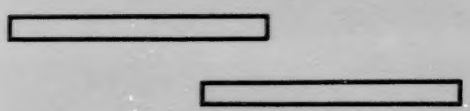
Procedure

E moves one of the sticks forward at least ¼ inch. The other stick is left unmoved for comparative purposes.

E: *"Now which stick is longer?"*

After S's response, E asks for justification: *"How do you know?"* or *"How are they different?"*

Regardless of how S responds, E moves the stick further forward and repeats the questions.



S might be asked to re-judge the situation when looking at the sticks from an opposite perspective. If S first judges the extension to the right, then S will reverse judgement if he does not conserve.

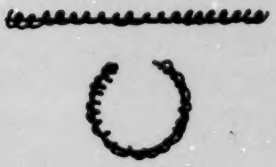
Checking Procedure

E: "*Let's pretend you dropped a piece of candy on the floor and it was too far away to reach. If you needed the longest stick you could find to reach the candy, which stick would you use?*"

After S responds, E asks: "*Why did you choose that stick?*"

Alternative Procedure

Two identical, flexible wires or pipe cleaners can be used. Keep one straight for comparisons and bend the other into a circle or S shape. Follow the questioning procedures above, and be sure that S realizes that the material is flexible (Even adults will ignore stretched out length unless told to judge on that basis).



Analysis

When S is asked which is longer and replies that neither one is longer. ("*Both are the same.*") and gives an appropriate explanation after each transformation, S is conserving the invariance of length. If S shifts his judgement for different transformations ("*This is longer.*" and "*Both are the same.*"), S may be in transition from being a non-conserver to a conserver. If S consistently states that the lengths are different, S is a non-conserver.

Solid Amount

Principle

The amount of a solid remains the same no matter how its shape is altered or divided (discounting expansion or contraction) (e.g., The amount of plastic in a toy remains the same even though it may be melted into a different shape; The amount of candy in a bar remains the same even though it may be broken into several pieces). Most students attain this ability by age eight or nine (Beard 1963, Elkind 1966, Lovell and Ogilvie 1960, Smedslund 1961).

Materials

6 balls of plasticene clay (same color) of which two are equal in size and appearance while the remaining are obviously different in size.

1 knife (for checking procedure).

Task

The student (S) is sitting opposite or alongside the experimenter (E).

E sets the six clay balls in front of S.

Establishing Initial Equivalence

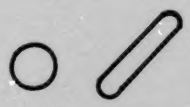
E: "*Pick out two balls of clay which look like they have the same amount of clay.*"

After S selects two clay balls, E removes all the remaining balls of clay. If S cannot find two balls of clay which are equivalent, E asks S to make two the same. If S cannot do so, then E discontinues the task. If S agrees upon equivalence, E continues with the following procedure.

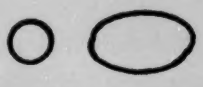
Procedure

E sets one of the clay balls aside for comparative purposes and says: "*Watch what I am going to do.*"

E rolls the other ball of clay into the shape of a sausage and asks: "*Now which has more clay?*"



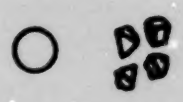
After S's response, E asks for justification: "*How do you know?*" Regardless of how S responds, E next reestablishes equivalence between the balls of clay, then flattens one into a pancake-shape and repeats the previous questions.



Checking Procedure

After equivalence is established as described, E cuts one ball of clay into fourths.

E: "*Now which has more clay?*"



After S's response, E asks for justication: "*How do you know?*"

E: "*Let's pretend that these* (pointing to the uncut and cut pieces of clay) *were pieces of candy. Which would you rather have?*"

After S responds, E asks: "*Why?*"

Regardless of how S responds, E next reestablishes equivalence between the balls of clay, then cuts one into eighths and repeats the questions.

Here as anywhere in conservation tasks, E can ask S what will happen if the tranformation is reversed (e.g., "*... if the cut pieces of clay are put back together*"). Will S maintain a non-conserving judgment or recognize the necessity for an empirical return?

Analysis

Consistency in statements of equality indicates that S conserves the invariance of solid amount. Consistency in statements of inequality indicates that S is a non-conserver. Fluctuations between the two types of statements indicate that S is in transition.

Liquid Amount

Principal

The amount (volume) of a liquid remains the same no matter how its shape is altered or divided (discounting expansion or contraction) (e.g., The amount of cola remains the same even though it may be poured into a differently shaped container or into several smaller containers). Most students attain this ability by age eight or nine (Beard 1963, Brison 1966, Vinh-bang and Inhelder 1966).

Materials

2 identical, transparent drinking glasses or jars with vertical sides. One contains about three inches of colored water and the other about two inches of identically colored water.

Food coloring (to make the water easier to see).

1 pitcher or jar of colored water.

1 tall, thin, transparent glass or jar.

1 low, wide, transparent glass or jar.

1 eyedropper.

6 small glasses (for checking procedure).

Alternative Materials

Kool Aid or other soft drink instead of water

Task

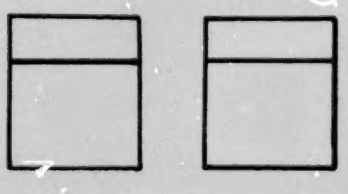
The student (S) is sitting opposite or alongside the experimenter (E).

The two identical glasses containing the liquid are placed in front of S.

Establishing Initial Equivalence

E: "*How can I make each of these glasses contain the same amount of water?*"

Following directions from S, E pours from the pitcher until S and E agree the two glasses contain the same amount. The eyedropper can be used to add or subtract small amounts from either glass.

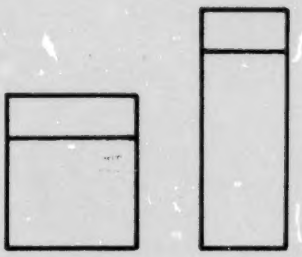


If equivalence cannot be obtained, discontinue the task. If S agrees upon equivalence, E continues with the following procedure.

Procedure

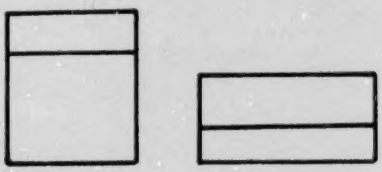
E sets one glass aside for comparative purposes and says: "*Watch what I am going to do.*"

E pours the liquid from one of the glasses into the tall, thin one and asks: "*Now which glass has more in it?*"



After S's response, E asks for justification: "*How do you know?*"

Regardless of how S responds, E reestablishes equivalence between the first two containers, then pours the liquid from one into the low, wide glass and repeats the questions.

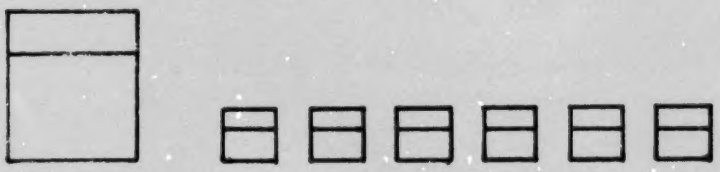


Checking Procedure

After equivalence is established as described, E pours the liquid from one glass about equally into each of the six smaller glasses.

E: "*Let's pretend that these* (pointing to the liquid in the comparative glass and the liquid in the smaller glasses) *are filled with your favorite drink. Which would you rather have?*"

After S responds, E asks: "*Why?*"



Analysis

Consistency in statements of equality indicates that S conserves the invariance of liquid amount. Consistency in statements of inequality indicates that S is a non-conserver. Fluctuations between the two types of statements indicate that S is in transition.

Discontinuous Length

Principle

The length of an object or line remains the same no matter how it is divided (e.g., The sum of the divided parts of a string is equal to its original length). Most students attain this ability by age nine or 10 (Beard 1963; Lovell, Healey, and Rowland 1962; Murray 1968; Smedslund 1963).

Materials

2 pipe cleaners about 12 inches in length.

1 pair of old scissors or wire cutters.

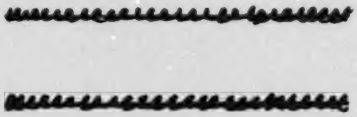
Alternative Material

Chenille kraft stems.

Task

The student (S) is sitting opposite or alongside the experimenter (E).

E places two pipe cleaners on the table so that they are parallel with both ends even. They will look like this:



Establishing Initial Equivalence

E: "*Are these pipe cleaners the same length or is one longer and one shorter?*"

If S does not agree to their equality, discontinue the task. If S agrees upon equivalence, E continues with the following procedure.

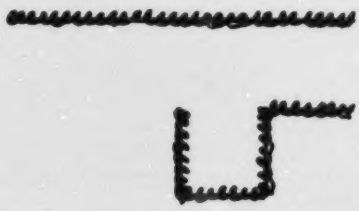
Procedure

E leaves one pipe cleaner untouched for comparative purposes and asks S to watch closely while E cuts the other one into four pieces which are arranged like this:

E: "*Now which is longer?*" or while pointing to the ends of both lengths asks: "*Which distance is greater?*"

After S's response, E asks for justification: "*How do you know?*"

Regardless of how S responds E next arranges the pieces in another way and repeats the questions.



Alternative Procedure

E may tell the story of two rabbits, each hopping down one of the roads (pipe cleaners) and may ask if either of the rabbits travels a greater or lesser distance. Or E might ask S to simulate the story by moving a finger along one road, then the other, before asking a question. (Be sure S focuses upon the distance and not the time it takes to travel from one end to the other.)

Analysis

Consistency in statements of equality indicates that S conserves the invariance of discontinuous length. Consistency in statements of inequality indicates that S is a nonconserver. Fluctuations between the two types of statements indicate that S is in transition.

Area

Principle

The total amount of surface covered by plain geometric shapes remains the same no matter how the shapes are rearranged (e.g., The area covered by a set of checkers remains the same whether they are close together or far apart). Most students attain this ability by age nine or 10 (Copeland 1979, Wagman 1968).

Materials

2 squares of brown paper (12" x 12").

2 identical figures of students.

16 cubical counting blocks of the same color.

Alternative Materials

Squares of a different color.

Task

The student (S) is sitting opposite or alongside the experimenter (E).

E places the two brown squares in front of S.

Establishing Initial Equivalence

E: "*These are school classrooms. Let's pretend that one is for your school and one is for mine. Are both the classrooms the same? Do you have as much floor to play on as I do?*"

If S does not agree to equality, discontinue the task.

E places a figure on each square and says: "*You have a person on the floor of your classroom, and I have a person on mine. Pretend that each person is going to paint the floor of his classroom. Does each have just as much floor to paint as the other?*"

If S does not agree to equality, discontinue the task.

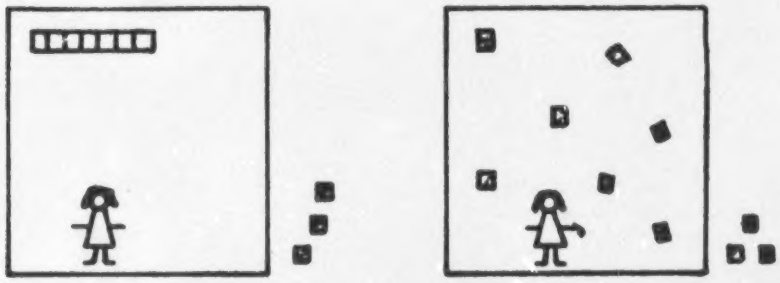
Now E places a block near a corner of one floor for comparative purposes and places a block in an identical spot on the other floor and says: "*Pretend that a book cabinet is placed in each room. One is put on my floor and one is put on your floor. Do the painters still have the same amount of floor to paint or does one have more and one have less?*"

If S does not agree to equality, discontinue the task.

If S agrees upon equivalence, E continues with the following procedure.

Procedure

E continues placing book cabinets, one at a time, on the floors making sure that the same number is placed on each but that on E's floor the cabinets are in a straight line while on S's floor they are scattered.



Each time book cases are placed, E asks: "*Now which painter has more floor to paint?*"

After S's response, E asks for justification: "*How do you know?*" or "*Is there some way you can prove your idea to me?*"

If S is not conserving, E discontinues the task after placing four blocks on each floor and asks: "*Is there a way you can move your book cabinets so that your painter has the same amount of floor to paint as mine?*"

Analysis

Consistency in statement of equality indicates that S conserves the invariance of area. Consistency in statements of inequality indicates that S is a non-conserver. Fluctuations between the two types of statements indicate that S is in transition.

Weight

Principle

The weight of a substance remains the same no matter how its shape is altered or divided (e.g., The weight of potato chips in a sealed plastic bag remains the same even though the contents are crushed into small pieces). Most students attain this ability by age 10 - 12 (Dasen 1972; Elkind 1961; Hall and Simpson 1971; Lovall and Ogilvie 1961; Miller, Schwarts, and Stewart 1973; Smedslund 1961,a, 1961,b; Smith 1968).

Materials

1 equal-arm balance scale.

6 balls of plasticene clay (same color) of which two are equal in weight and appearance.

1 knife (for checking procedure).

Task

The student (S) is sitting opposite or alongside the experimenter (E).

E sets the scale and six clay balls in front of S.

Establishing Initial Equivalence

E: "*Pick out two balls of clay which weigh the same.*"

S selects and places the clay on the balance. S can add clay to or subtract clay from a ball of clay to achieve balance. If S cannot establish equivalence by weight, E discontinues the task. If S establishes equivalence by weight, E continues with the following procedure.

Procedure

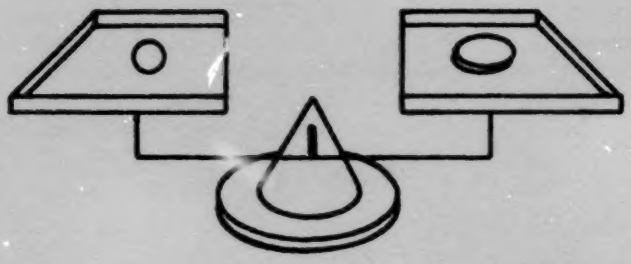
E leaves one of the balls of clay on the balance scale for comparative purposes and says: "*Watch what I am going to do.*"

E rolls the other ball of clay into the shape of a sausage and asks: "*Now which do you think will weigh more?*"

After S's response, E asks for justification: "*How do you know?*"

If S wishes, S can check the response by placing the clay back on the scale.

Regardless of S's response, E next re-establishes equivalence by weight, then flattens one ball of clay into a pancake-shape and repeats the previous questions.



Checking Procedure

After equivalence by weight is established as described, E cuts one ball of clay into fourths.

E: "*Now which weighs more?*"

After S's response, E asks for justification: "*How do you know?*"

Regardless of how S responds, E next reestablishes equivalence by weight, then cuts one clay ball into eighths and repeats the questions.

Analysis

To conserve weight, S must conclude that the weight of an object, as well as its gross amount of matter, remains constant throughout changes in shape. Weight conservation may be thought of as solid amount conservation with an added weight judgment. If S consistently states that the weight remains the same after each transformation, S conserves the invariance of weight. If S consistently states that the weight is changed, S is a non-conserver. If S is inconsistent in these judgments, S is in transition.

Solid Volume

Principle

The amount of space occupied by a solid material remains the same no matter how its shape is rearranged or transformed (discounting expansion or contraction) (e.g., A pile of bricks takes up the same amount of space after the pile has been knocked down). Most students attain this ability by age 12 - 14 in spite of the obvious similarity of this task to the conservation of solid amount, attained four years earlier, and more strikingly, with conservation of number, six years sooner (Elkin 1961, Lovell and Ogilvie 1961).

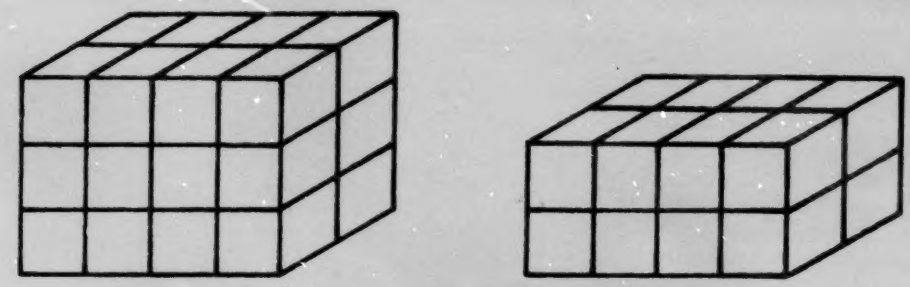
Materials

50 cubical counting blocks of the same color.

Task

The student (S) is sitting opposite or alongside the experimenter (E).

E constructs a 2 x 3 x 4 stack of blocks (3 blocks high) and a 2 x 2 x 4 stack (2 blocks high). They will look like this:



Establishing Initial Equivalence

E: "*Do the stacks have the same amount of wood in them or does one have more and one have less?*"

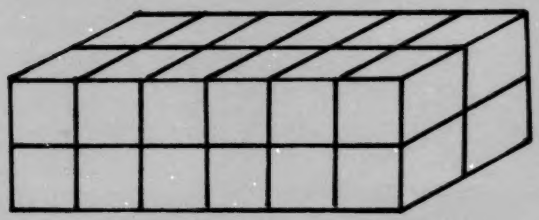
E allows S to add blocks to the smaller stack until S and E agree that the two stacks contain the same amount of wood.

If equivalence is not obtained, discontinue the task. If equivalence is agreed upon, E continues with the following procedure.

Procedure

E: "*Now watch what I am going to do.*"

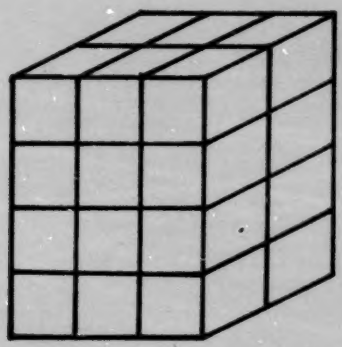
E leaves one stack unchanged for comparative purposes and rebuilds the other stack to form a 2 x 2 x 6 stack (2 blocks high).



E: "*Do the stacks have the same amount of wood in them now or does one have more and one have less? Do the stacks have the same number of blocks or does one have more and one have fewer?*"

After S's response, E asks for justification: "*How do you know?*" or "*Is there some way for you to prove your idea to me?*"

Regardless of how S responds, E next reestablishes equivalence, then rebuilds the smaller stack to form a 2 x 3 x 4 stack (4 blocks high). E repeats the questions.



Alternative Procedure

E may tell the story of identical buildings (2 x 3 x 4) which have the same number of rooms in each (each room represented by one block). The buildings are on identical islands. One building burns down and is rebuilt with a 2 x 2 base. Before rebuilding it, E asks: "*Could you tell in advance how tall the building will be? How many stories would there be to have just as many rooms as the other building?*"

Analysis

This task involves the notion of inverse proportionality (smaller base, so a taller building) which is revealed in qualitative rather than numerical tasks. Consistency in statements of equality indicates that S conserves the invariance of solid volume. Consistency in statements of inequality indicates that S is a non-conserver. Fluctuations between the two types of statements indicate that S is in transition.

Displacement

Principle

The amount of liquid that an object displaces remains the same no matter how the object's shape is changed (e.g., A ball of clay that causes the level of water to rise 10 ml when submerged, will cause the same displacement after being flattened into a pancake shape). Most students attain this ability by age 14 or 15.

Materials

6 balls of plasticene clay (same color) of which two are equal in size and appearance while the remaining are obviously different in size.

2 identical, transparent drinking glasses or jars with vertical sides.

1 pitcher of water.

1 eyedropper.

1 knife or cutting tool (for checking procedure).

Task

The student (S) is sitting opposite or alongside the experimenter (E).

E sets the six clay balls in front of S.

Establishing Initial Equivalence

E: "*Pick out two balls of clay which look like they have the same amount of clay.*"

After S selects two clay balls, E removes all the remaining balls of clay. If S cannot find two balls of clay which are equivalent, E asks S to make two the same. If S cannot do so, E discontinues the task.

E sets one of the clay balls aside for comparative purposes and gives the other one to S.

Next, E places two drinking glasses, a pitcher of water, and an eyedropper in front of S and says: "*Pour water into the glasses so that there is an equal amount in each.*" The eyedropper can be used to add or subtract small amounts of water from the glasses.

If S and E do not agree on equivalence, discontinue the task. If equivalence is agreed upon, E continues with the following procedure.

Procedure

E: "*Now watch what I am going to do.*"

E places one ball of clay into one glass of water and asks: "*What happened to the level of the water?*" (The water level is now higher). NOTE: The clay must be of enough amount to make a change in level obvious.

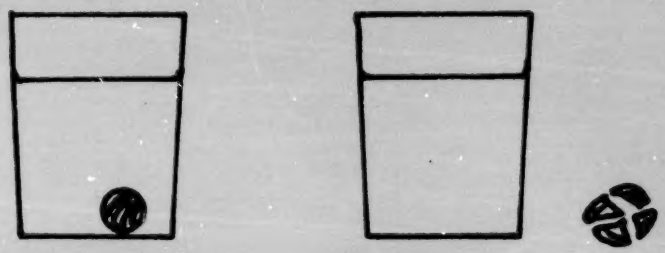
E next rolls the second ball of clay into the shape of a sausage and asks: "*If you drop this into the other glass, what will happen to the water level?*"

After S responds, E directs S to put the clay into the glass and asks: "*How can you explain what happened?*"

Regardless of how S responds, E next reestablishes equivalence between the balls of clay and the amount of water in each glass, then repeats the procedures and questions after flattening one ball of clay into a pancake shape.

Checking Procedure

After establishing equivalence between the balls of clay and water in the glasses, E cuts one ball of clay into fourths and repeats the questions.



Analysis

Consistency in statements of equality indicates that S conserves the invariance of displacement. Consistency in statements of inequality indicates that S is a non-conserver. Fluctuations between the two types of statements indicate that S is in transition.

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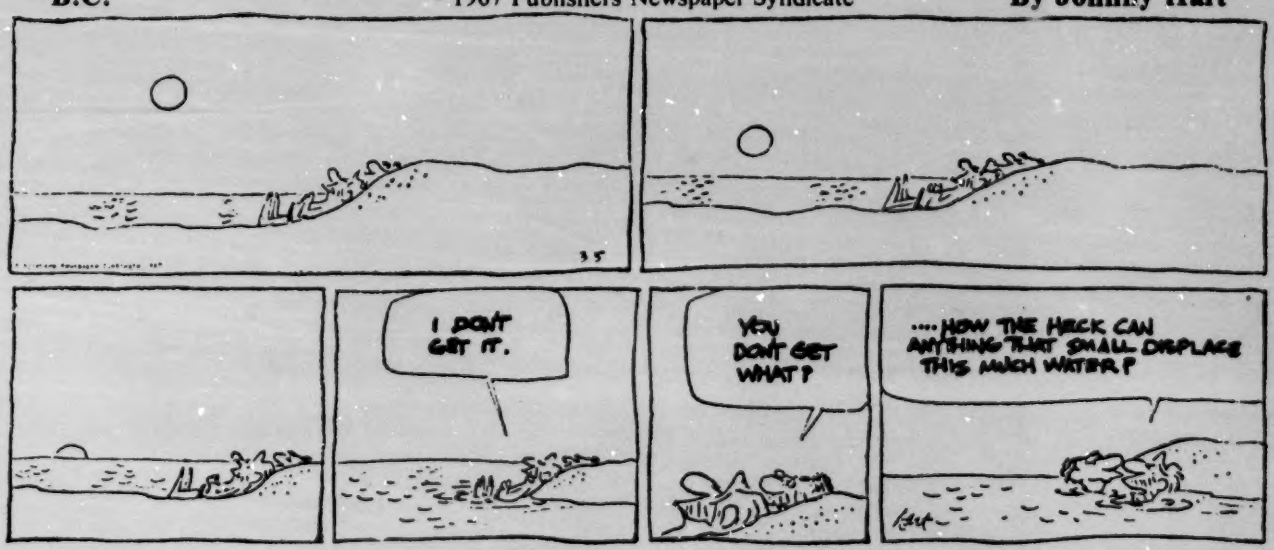

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The following pages contain
several self-directed workshops.

Except for the first workshop,
the order in which they are done,
the number that are done,
and the time it takes to do them
are up to you.

WORKSHOP **A**

refining the ability to administer conservation tasks

The purpose of this personal workshop is to guide you in practicing the tasks shown in the previous section. After finishing this workshop, you should be able to properly select students and to skillfully use a clinical method while administering the tasks.

Study the Guidelines on the following pages, then practice administering the Relational Terms Test with a friend.

Next, give any two of the conservation tasks to the friend and consciously incorporate some of the ideas from the guidelines.

Additional copies of the checksheet for the Relational Terms Test are found in the Appendix.

Use the space below to jot down personal notes about your practice experiences.

Some Guidelines for Administering Conservation Tasks

1. *Relational Terms.* Before administering a conservation task, you must be certain that the student thoroughly understands the words you might use.

   At the end of this section is a Relational Terms Test. This test will tell you whether or not the student can discriminate between such terms as *same* and *different; more* and *less; more* and *fewer; higher* and *lower.*

   Do not administer a conservation task without first being sure the student understands the appropriate relational terms. But remember that understanding such terms does not imply that the student can spontaneously use them. The student may use absolute terms (e.g., "*A lot here and a little there*"). As an alternative to finding out understandings of relational terms, you might find out what terms the student does use for the relational concepts.

2. *Equivalence.* It is imperative that equivalence be established before rearranging or transforming one of the situations in a conservation task. Moreover, it is the student who must establish the equivalence, preferably through his or her own actions. Each of the tasks in this set has provisions for doing this.

   Initial equivalence between two situations establishes a baseline upon which other judgments can be made by the student being interviewed. Without equivalence, a student's judgments and statements become ambiguous to the experimenter, and it is often impossible to determine on what aspects a student bases his comments.

   To make sure equivalence has been established, a particular relational term can be used. For example, when materials are compared for equivalence, you might ask: "*Are there more red chips (or other material) or more white chips?*" It has been found that when the term *more* is used, the student who really feels that equivalence has been established, will not accept the term as a hidden suggestion, while the student who seeks a clue from the experimenter or who is not capable of establishing equivalence, will not accept the materials as being equal. In the latter case, it is wise not to proceed with the task. In the former case, you can be assured that the student has established equivalence. The relational term can again be used after each transformation of the material. The reuse will help identify non-conservers and conservers, for the latter will not be misled by the idea of *more.*

3. *Rearrangements and Transformations.* Each conservation task in this set has the experimenter retain and keep unchanged, one of the two equivalent situations. The unchanged situation allows the student to make comparisons with the changed situation. Always let the student manipulate the materials and compare the two situations.

   Each task also includes procedures for changing a situation more than once. For example, after equivalence is established between two balls of clay, one ball is reshaped and questions are asked (a). Regardless of the student's response, the ball is reshaped, and the questions are repeated (b).

The second change in a situation provides the experimenter with an internal check on the student's judgments and statements. The second check often reveals inconsistencies in the student's thinking (e.g., After the first change, the student might judge the reshaped ball to contain the same amount of clay, but after the second change he might state that there is now less clay because it is "thinner"). Inconsistencies, such as the one in this example, are sometimes indicative of students in transition—that is, students who are between being preconservers and conservers.

4. *Checking Procedures.* A few of the tasks in this set provide alternative and/or checking procedures. These additional procedures give suggestions for making sure the student understood the task and your questions and that you understood the student. The procedures can help you verify information.

5. *The Assessment Method.* Although this set of tasks has the appearance of a standardized test, each task is not meant to be given as such. There should be improvisation over and above the suggested statements and procedures. Improvisation will come with practice and experience. Essentially you should follow a method whereby you are constantly formulating hypotheses as to the strategies used by the student, testing the hypotheses through manipulations of the materials, and asking the student for justifications for what he or she does.

Relational Terms Test

Purpose

To determine student's understanding of particular relational terms: *same, different, more, fewer, higher, lower.* Using this test as a model, other tests can be devised to examine other relational terms.

Materials

9 red poker chips.

9 white poker chips.

Alternative Materials

Checkers.

Test

The student (S) is sitting opposite or alongside the experimenter (E).

E places a pile of nine white chips and a pile of nine red chips in front of S.

Procedure

E tests comprehension of the term *same* by asking, "*Do both piles have the same amount or does one have more and one have less?*"

After S's response, E asks for justification, "*How do you know?*"

E tests comprehension of the term *different* by moving five chips from the white pile and asking, "*Does the white pile have a different amount or the same amount?*"

After S's response, E asks for justification, "*How do you know?*"

E tests comprehension of the term *more* by placing four white chips next to the nine red chips and asking, "*Are there more red chips or more white chips?*"

E tests comprehension of the term *fewer* (in the same situation) by asking, "*Are there fewer white chips or fewer red chips?*"

E tests comprehension of the term *higher* (in the same situation) by asking, "*Is the white pile higher than the red pile or is the red pile higher than the white?*"

E tests comprehension of the term *lower* (in the same situation) by asking, "*Which pile is lower?*"

For each of the above questions, E asks for justification, "*How do you know?*" or "*Is there something you can do to explain your idea to me?*"

The check sheet on the next page can be used for keeping a record of the relational terms understood by your students. Additional copies are placed in the Appendix.

Understanding Relational Terms Checksheet

Student	Terms								
	same	different	more	less	higher	lower	other terms		

WORKSHOP **B**

practicing the administration of the assessment method

The purpose of this workshop is to guide you in practicing the use of the assessment method when presenting conservation tasks. After doing this workshop, you should be better able to use the method.

Prepare an audio- or videotape of yourself administering a conservation task to a student.

At your leisure, review the recording and use the form on the next page to guide your analysis of your use of the assessment method.

The following are guidelines for administering conservation tasks.

1. *Purpose.* The purpose for administering conservation tasks is to determine the nature of the student's thinking concerning conservation.

2. *Situation.* The tasks presented in the previous section of this book are best administered on a one-to-one basis in a private place. After much practice, it is possible to carry out the procedure during natural classroom activities.

   Prior to the administration of the tasks, be sure the student understands the terms to be used or adjust your presentation to use the student's terms.

3. *The Assessment Method.* A good assessment of a student is not the result of following a prescribed procedure word for word although as you begin, word for word practice is important in developing a sense of good assessment technique. The heart of the assessment method rests in being attentive to what the student does, how the student explains what is done, and in making educated guesses (hypotheses) about the student's behavior. Making educated guesses during the interview allows you to continually generate questions that further your understanding of the student's reasoning. Developing your skill in the assessment method takes time and practice.

   When you begin, present the materials to the student in a natural manner. For example, you might say, "*Let's work with these for awhile*" or "*I have some things I want you to do with these.*" Get directly into the interview rather than provide explanations about what you are going to do.

As you administer the tasks, ask the student questions which refer to the objects you have presented. To obtain behavioral as well as verbal responses, have the student manipulate the objects and give a rationale for what is done.

As you interview, be genuinely curious about and interested in the student's ideas. Do not be thinking about other things such as the papers that must be graded or the party you are going to. Not being "with" the student is quickly detected and will adversely affect the assessment. The basis for being "with" the student is to find out how he or she reasons.

During the interview, ask questions which challenge the student's idea in order to determine how firmly the student holds a belief or why the student believes as he or she does. Do this in a supportive, accepting, and non-judgmental way without leading the student to ideas you expect to find. A typical mistake in beginning interviews is the attempt to get the best and most advanced response from the student. Once a student gets the sense that you want something, the interview is affected. It is important to let the student lead while you follow, asking simple questions that reveal to you the student's thinking.

Be flexible in interviewing. If the student does not understand what you ask, rephrase your question. If the student does not do what you ask, let the student fool around with the materials a while. Some students need time to become comfortable with the materials. However, if the student drifts, remind him or her of what you want. This is important because a drifting student will do whatever he or she wants and you will learn little. To get the student back on track, you might say, "*You can play with the blocks in any way you like after we've finished, but now I want you to...*" With practice and by being flexible, you will be able to incorporate any spontaneous activity into the interview by asking the appropriate questions concerning the thinking you are assessing.

Although scripts indicating what to say are presented in this book, they serve only as a starting place. The questioning strategy to be used is not standardized. It should remain fluid and become part of your style. As you observe the student's manipulation of objects, listen to the responses and form guesses about the student's thinking, use your questions to test your hypotheses and, if necessary, to form other hypotheses about the student's ideas.

Be careful not to talk too much. This often confuses or leads the student into a particular line of thought. Give ample time for responses to your questions. Pause as long as necessary, and do not rush the student's thinking by asking a new question too soon.

The administration of a task should be pleasurable for you and the student. If you or the student is uncomfortable, it is best to discontinue the interview, and to try again at another time.

Self-Assessment: Using the Assessment Method	
Assessment Considerations	Personal Notes
a. What aspects of the interview indicated that I was non-judgmental and accepting of the student's ideas?	
b. What examples in the interview indicated that I avoided leading the student toward an idea I had?	
c. What evidence is there that I let the student's responses and actions guide the discussion?	
d. What evidence indicates that I approached the student at his or her level and responded to the situation independently of adult expectations of how he or she should act?	
e. What evidence indicates that I formulated hypotheses concerning the student's strategies and tested the hypotheses through manipulations of the materials?	
f. In what ways did I check for justifications?	

WORKSHOP **C**

assessing the administration of conservation tasks

The purpose of this workshop is to guide you in the assessment of your ability to administer conservation tasks. After doing this workshop, you should be better able to administer such tasks.

Prepare an audio- or videotape of yourself administering a conservation task to a student.

At your leisure, review your recording and use the questions below to guide your assessment of your work with the student.

		Yes	No
1.	Did I give a Relational Terms Test before presenting the conservation task to be sure the student would understand the words I would use?	☐	☐
2.	Did I establish equivalence before beginning the task?	☐	☐
3.	Did I make more than one transformation during the task, and did I reestablish equivalence before each additional transformation?	☐	☐
4.	Did I ask questions which could not be answered by a simple *yes* or *no* by the student?	☐	☐
5.	Did I allow/encourage the student to manipulate the materials?	☐	☐
6.	Did I employ a checking procedure (using a different story or different materials)?	☐	☐

If your response to any of the above questions was *no*, you might find it profitable to reread the directions for administering conservation tasks.

WORKSHOP **D**

administering conservation tasks

at different levels of development

The purpose of this workshop is to let you compare different levels of responses to the same experience. After doing this workshop, you should be able to better identify the level of ability of different students.

Select one conservation task and administer it to three different students: one primary, one intermediate, and one high school.

At your leisure, compare the students' responses in terms of the analysis given for the task you selected.

You may wish to audio- or videotape this experience so that you can discuss the information with a colleague.

WORKSHOP **E**

administering conservation tasks to students

The purpose of this personal workshop is to guide you in administering conservation tasks to students in your own classroom. After finishing this workshop, you should be able to administer the tasks and record the responses of the students.

Use the suggested record sheet on the next page (or a variation of it) to obtain data on several students in your classroom.

Videotape one of your sessions so that the experience can be added to your collection of videotapes.

Have a staff member discuss your tape with you, especially your use of the assessment method.

Additional copies of the record sheet are found in the Appendix.

Record of Conservation Tasks

Student's Name:_____ Age_____

Administered by:_____

Task	Student's Responses	P	T	C	Administrator's Comments	Date
Number						
Continuous Length						
Solid Amount						
Liquid Amount						
Discontinuous Length						
Area						
Weight						
Solid Volume						
Displaced Volume						

P = Pre-conservation
T = Transition
C = Able to Conserve

WORKSHOP **F**

administering conservation tasks

to a student

The purpose of this workshop is to guide you in assessing the ability of one student. After doing this workshop, you should be able to identify a student's level of development in relation to this ability.

Select a student in your classroom about whom you want to learn more. Administer one or more conservation tasks which you feel will reveal the student's stage of development.

At your leisure, study the student's responses in terms of the analysis given for each task you used. Keep a record, diary or profile of the assessment. Decide what kinds of experiences would be suitable in a learning experience for this student.

You may wish to audio- or videotape this experience so that you can discuss your assessment with a colleague.

WORKSHOP **G**

identifying cognitive operations related to conservation abilities

The purpose of this workshop is to give you practice in identifying cognitive operations in a different context. After this workshop, you should have a greater skill in transferring what you have learned to new situations.

Read the comic strips below. Each ends on a humorous point that requires a cognitive operation for understanding. Try to explain each humorous point in terms of what you have learned in this program (HINT: It might be helpful to reread the Introduction).

When finished, check your explanations with those given on the following page.

1.

TUMBLEWEEDS **© King Features Syndicate 1974** **-By Tom K. Ryan**

AS YOUR CHIEF, I'D PLANNED TO LEAD YOU INTO BATTLE, MEN!... HOWEVER, I'VE DEVELOPED A SPLITTING HEADACHE, WHICH WILL CONFINE ME TO MY TEEPEE! FEAR NOT THOUGH! I'LL BE LEADING YOU IN SPIRIT!
11-28
GOLL'! YER BRAVE, CHEEF! YER MY IDLE!
WHY... THANK YOU, MY BOY!
TAKES GUTS T' COP OUT IN FRONTA THE HOLE TRIBE!

2.

B.C. **-By Johnny Hart**

By permission of John Hart and Field Enterprises Inc.

Analysis of Comic Strips

1. Naturally, the humor in a comic strip such as this one is very complex, however, an aspect related to reversibility can be recognized.

   The statement in the last frame requires that the reader return to the statement in the first frame. To understand the joke, you must negate or invert your original interpretation (which was cleverly reinforced in the second frame).

2. This comic strip also involves reversibility via negation-inversion. You must return to the interpretation originally made of the statement in the first frame and replace it with an opposite interpretation.

   Reversals of ideas often catch us by surprise, and we tend to enjoy such turns in events. Because of this, reversals are often used as a basis for humor.

WORKSHOP **H**

observing the administration of conservation tasks

The purpose of this workshop is to provide additional practice in assessing levels of development and in analyzing interviewing procedures. After finishing this workshop, you should be able to better identify levels of conservation abilities.

View the PDARC videotape on Conservation Abilities* with several other teachers. The tape will show students at different levels of cognitive development responding to a conservation ability task.

When you finish viewing the tape, discuss the following with your colleagues:

1. What clues were observed that indicated the stage of development for each student interviewed?

2. Compare the responses of the students on this tape with responses of those you have interviewed (e.g., in Workshops B, C, D, E, or F).

3. Did the interviewer use the assessment method throughout each interview?

*Videotape available from: Professional Development and Applied Research Center, Graduate School of Education, University of California, Berkeley, CA 94720.

WORKSHOP **I**

reading about

conservation abilities

The purpose of this personal workshop is to provide for your study, a curriculum-research topic that is related to the subject of this book.

At your leisure, read the following article from *Science Activities,* January 1973. The article will add to your understanding of conservation abilities.

PIAGET AND THE NATIONAL CLAY BOAT CONTEST

Michael B. Leyden

Science Education
Eastern Illinois University
Charleston, Illinois

Student molds clay boat which she hopes will float in adjacent container of water. Porcelain weights are in foreground.

Explaining why an object floats usually requires dense thought. Unfortunately, students often escape the ignominy of logical mental operations by memorizing an axiom which states that objects float if they are less dense than water, and sink if their density is greater than that of water.

Parrotting "the facts" not only makes students immune to thought, but bails them out of trouble—winning points on science exams, and buying them a passing grade in "the course." It shouldn't. Such rote behavior provides the teacher with nothing of value on which to base student learning.

How children ever develop the cognitive schema needed to actually explain sink-float phenomena is a mystery which will not be unraveled here, although some interesting points may surface.

Floating and the Frenchman

Pelecypods are those hard-shelled animals with soft interiors often found at clambakes. People, with their soft exteriors and internal skeletons, are also found at clambakes. Had Jean Piaget one wish, he might have chosen to operate a clam stand—so that he could study his favorite topics: mollusks and people.

Whether the Swiss-born Frenchman ever operated a clam stand is doubtful, but his studies of "shellfish" and people are well documented. During his collegiate youth he majored in biology, inking a dissertation regarding mollusks, that phylum whose members possess floating skills in varying degrees. Clams are expert in sink technique, while many gastropods and cephalopods buoy with ease.

Once Piaget abandoned his marine environs of invetebrates in favor of the terrestrial study of children, the topic of floating again arose.

Children spend about a third of their young lives getting dirty, and another third cleansing the soil from their bodies. The remaining time is spent in slumber: dreaming of new ways to get dirty. They log endless hours playing with toys in the bathtub—making many manipulations and observations of floating and sinking objects. They graduate to swimming pools and lakes where they participate in a variety of aquatic activities. With their consciences whetted from such lengthy laboratory sessions obtained while basking in fluid (i.e. concrete experiences), why do they have so much difficulty moving to the abstract phase where they must verbalize their ideas concerning sink-float causation?

Floating and the freshmen

Applying Piagetian thought to the floating problem, Joe McKinnon interviewed 157 college freshmen regarding their ability to explain the floating process. He proposed a six-step hierarchy which must be mastered to ensure a rational explanation of why things float. At the lowest level were two problems involving Piaget's clay-ball tasks for determining the presence of the mental constructs involving the conservation of weight and volume. Seventeen percent (24 students), and 27% (41 students) could not pass the respective tasks.[1]

Such data seem unbelievable, and many might question the findings. While the author did not question McKinnon's study, he did wonder about the fate of EIU students when faced with a similar problem. But this is getting ahead in our sea saga.

Launching an idea

Students in the science-methods class at Eastern were "messing around" with the Elementary Science Study (ESS) Clay Boat unit. One student succeeded in piling 92 porcelain chips in her boat without total subsidence. By the end of the second day, 195 chips became the prize cargo. With all students using about 150 grams of clay, the class competition continued until 432 chips were floating precariously in a barely floating clay vessel. Estimating the weight of each wet chip as 2.5 grams, one can see that the wining student had stowed about 1,200 grams in his craft.

Because no one else could come close to matching this record, the students formulated "the rule of floating." To wit: "The maximum weight that a ship can carry is about eight times the weight of the hull." (Note: 150 grams of clay x 8 = 1,200 grams) Archimedes recant.

As significant as the 1,200 gram figure seemed to be, the class began to wonder about the "world record" for clay-boat freight. Since no such data was available in the archives, an empirical study was made by sending

a Clay-Boat Challenge to 50 colleges during the following quarter.

Piaget and clay

It was intended that all participating classes be tested with Piaget's clay-ball tasks in hope of producing a large amount of data. Since only six colleges responded, and no standard method of presenting the tasks could be prescribed, the idea was laid to the abyss.

Mass testing of students, no matter how small the group, is definitely not Piagetian. His was a clinical method: a one-to-one interview technique. In such a situation the interviewer poses a problem and lets the child manipulate the materials and explore in a self-directed manner. Because Piaget was developing a theory of intellectual growth, his theory could not be incubated in regimented sessions.[2]

Clinical interviewing techniques are difficult to achieve and take months of practice in the art of talking to children before an acceptable repartee can be established. It is difficult for testers, particularly those who have been trained as verbally-oriented classroom teachers, to learn how to listen. If the tester takes command of the dialogue, he may easily lead the witness. The good examiner knows how to observe the child's behavior without channeling him into a desired response, and at the same time is cognizent of statements which do hold significance. Even when the interview is over, there are dangers for the inexperienced interpreter. The novice may easily read too much or too little into each student response.[2]

Individual testing of the 55 EIU students who would enter the clay boat contest was impractical. A group technique had to be attempted.

Dr. John Renner, a recognized leader in science education and child learning, was consulted with regard to group testing with the clay-ball tasks. He stated that the most meaningful part of any interview was the opportunity for the student to explain his answers. The student's answer is not nearly as important as his reasons for proposing such a comment. He added that although they (at the University of Oklahoma) have not had too much success with group testing, they were going to try again because if an acceptable mass testing technique could evolve, it would lend valuable information about the thinking in children.

Prompted by Renner's remark they would try again, the writer believed that it was important to at least attempt group testing.

Two groups of freshmen in a general education course and four sections of seniors in a science methods course became the first group test population. Except for the freshmen who were quizzed in groups of 22 and 23, all of the test sections were limited to 15 students.

Test technique

Testing for the concept of weight conservation was done as follows. The students were shown two clay balls which were placed on a pan balance. They weighed the same. One of the balls was then rolled into a cylinder, and they were asked: "If I put the two clay objects on the balance again, will they still weigh the same? Merely write yes or no on your paper, and explain your answer." See Figure 1.

In a similar manner, the test for the conservation of volume was administered. A string was tied around a paper clip and the wire straightened and pushed thru the clay. The sphere was lowered into the water and then extracted. The students were asked: "If the cylinder is lowered into the water, would the water level rise the same amount as it did for the sphere? Again, write yes or no, and explain." See Figure 2.

	FRESHMEN	SENIORS	TOTAL
CONSERVATION OF WEIGHT	2/45 = 4.4%	6/81 = 7.3%	8/126 = 6.3%
CONSERVATION OF VOLUME	23/45 = 51.1%	31/81 = 38.3%	54/126 = 42.9%

Figure 3. *Results of test for concept of weight conservation.*

Figure 3 lists the results obtained by the procedure described. While the author has severe reservations concerning the validity and reliability of this information, he also believes that such data should be presented for public consumption and criticism. The reader's help is solicited for improving the method by which to word, administer, and evaluate such group tests.

Even if the percentages in Figure 3 are in error by a factor of two or

Figure 1. *Two clay spheres weighed the same. One sphere was rolled into cylinder. About 6% of students thought cylinder would weigh less than sphere.*

Figure 2. *About 43% of students thought clay cylinder, clay sphere would displace unequal amounts of water.*

three, the results are still shocking when one considers that they were collected from college students.

All of the comments from the eight non-conservers of weight are produced below. The first two are from freshmen, and the others reported by seniors.

No, clay that was rolled would weigh more because it's more concentrate.

No, because the round ball has more area and will weigh more.

No, because they have different volume.

No, because of the distribution of the weight.

No, area may affect the scales.

No, the cylinder covers less area—a different shape.

No, because you's changed the shape.

No, because the shape has been shifted around.

Twenty-three freshmen stumbled on the conservation of volume task. A sample of seven of their comments is recorded below.

No, because the sphere will be more dense and force the water up more than would the cylinder.

No, the rolled piece has been compressed more than the ball so it won't take up as much space.

No, the clay ball covers more area and more surface area must be replaced. The cylinder does not cover as much area and therefore the water will not rise as much.

No, the clay ball covers more area and more water would rise higher than the cylinder.

No, greater area covered the more water will rise.

No, water rises more in rolled clay container because less area in width of clay.

No, they weigh the same, but their mass is different.

Fifty-four seniors were non-conservers. Fourteen sample responses are cited.

No, because the water surrounding the object would be different.

No, because the ball of clay is more compact and as such it will cause the water to rise more.

No, because the cylinder shape of one has more surface area exposed.

No, the cylinder would rise to a higher level.

No, their surface areas are different so they would displace different amounts of water.

No, the cylinder will take more space. Its area surface is more than that of the sphere.

No, the displacement of water is relative to the surface area.

No, the sphere would displace more water—its diameter is larger.

No, cylinder shape has less width and would displace less water.

No, cylinder would cause water to rise lower than sphere because the weight is more evenly distributed than the sphere.

No, the water probably wouldn't go up the same, because since the objects are different shapes, they would displace the water differently.

No, the water will go up different because the sphere does not have as much surface area hitting it as the cylinder.

No, because the volumes of a sphere and cylinder differ.

No, because they have different volumes and each will displace its volume.

Displayed in all these answers is a multitude of logic. Despite the apparent lack of logic, logic is exhibited; i.e., the answer makes sense to the student. Regarding the volume problem, note how many students focus on the surface area as the dependent variable in water displacement. When supplied with a complete list of student responses, Dr. John Renner remarked that the comments were amazingly similar to the thinking exhibited by students during personal interviews that he had conducted.

Although students answered the questions anonymously, the behavior of the non-conservers betrayed their identity as they molded clay boats: e.g., "What are you doing? Why are you rolling the clay so thin?" "I'm making the clay weigh less and take up more space. That will make the density get less, and it will float."

There can be little doubt that this student can "define" density as mass divided by volume. She also "knows" that if the numerator (mass) gets less, and the denominator (volume) increases, the density will drop. She also "knows" that objects with a "low" density float in water. And while her fantastic bit of double negative thinking (i.e. the mass of clay decreases as the volume increases) leads her to "the answer," it is obvious that something is mentally amiss.

Now the coed was taken aside and "tutored" in the conservation of weight and volume. When she saw that the balance indicated that the clay cylinder and sphere weighed the same; and the displacement of water was identical, she gasped and said: "I still don't believe it!" An identical comment was reported by Stendler when reporting about testing two children with Piagetian tasks.[3]

Conversations with other students during their clay boat making experience indicated that there were definitely many non-conservers in the group. Whether the percentage of these students is equal to the level indicated by the group test is not clear, but this experience has shown that group testing has some credence.

Victory at sea

Many paragraphs ago there was an allusion to something called The First National Clay Boat Contest; and it was from this pier that the Piagetian implications of such a match were launched and have since been discussed. Now we focus on the results of such competition, and christen plans for a new year.

Despite their apparent lack of conservation skills, Eastern students proved to be more than adequate shipbuilders. Only one coed considered the liquid as a possible variable in the success of her flotation effort. She remembered hearing that people float easier in salt water than they do in fresh water. Could she use salt water? When questioned why salt water would aid the cause, she could not elaborate, but her ideas were ripe for further exploration. She was secretly given some salt, alcohol, and a hydrometer to independently explore this floating facet. Since she was the only student to think of using a brine solution, there was no reason to publicize her theory and have other participants blindly mimicking her. As the only saline sailor, her craft held 728 grams.

Before the results received from the other colleges were unsealed, Eastern students were required to finish their boats.

At this time, a new clay-boat challenge is issued to the plasticine potterers of the world. Enter your teams by sending the information requested

REGISTRATION FORM

NAME:_____

SCHOOL:_____

ADDRESS:_____

COMPETITION LEVEL: JHS Grades: 7 8 9
SHS General Science Earth Science
Physics Misc.
COLLEGE Science Methods Physical Science
Physics

ALL DATA MUST BE FILED BY FRIDAY, MAY 11, 1973.

CLIP THIS, AND SEND ALONG WITH 50¢ FOR EACH PARTICIPATING CLASS TO:

Dr. Michael B. Leyden—Education Department—E.I.U.: Charleston 61920

Please feel free to make any comments and suggestions concerning the conduct of Clay Boat II.

Figure 4.

in Figure 4 along with the entrance fee to the address cited. The rules governing the contest are the same as last year. Floating boats in salt water is permissible only if the idea evolves from the student. Floating boats in mercury or other heavy liquids is not permitted regardless of where the idea originates. There will be Team and Individual awards at three levels of competition: junior high school; senior high school, and college. Any suggestions for improving the contest will gladly be considered.

Torpedoed

With their clay rolled into drydock and the unit completed, students were given a three-question homework assignment concerning abstract floating concepts.

Very few missed the first question, but the others were more difficult, and proportionally more students found themselves listing from leaking logic.

Read the answers below, and analyze what has caused students to form such perceptions.

Question One: You have a rectangular piece of wood that measures 5cmx 10cmx20cm, and weighs 500 grams. Show your calculations and make a sketch which illustrates how deep this block will sink in water when it is placed on end: on its narrow side, on its broad side.

Maybe there is security in mathematical manipulation. Students can "get the answer" by processing the numbers. One coed remarked that this was a trick question since the wooden block couldn't possibly float on "end" because it would flip over to become more stable.

Question Two: Someone in this class stated that the reason things float is as follows: A floating object will sink to the depth at which the upward pressure exerted by the water is equal to the downward pressure created by the weight of the object. If this is true, then if an object continues to sink in the ocean, shouldn't the pressure on the bottom of the object eventually increase to a point so that it is greater than the weight of the object—thus making the object "float" (e.g.) 200 feet under water, but yet 300 feet from the ocean floor? Comment on this logic.

Yes, that's right. The logic is okay.

Yes, this point is called the equilibrium point.

Yes, in some cases this would be true because how far the object sinks depends upon such factors as the density and weight of the object and the density and depth of the water.

Yes. this is true. As you go deeper there is enough pressure exerted upon the object that the density (weight) of the water becomes equal to the density (weight) of the object, and the object begins to float.

For the most part, students did not become confused by this question, and, as one person stated, "No, this kind of logic is all wet, and here is why . . ."

Question Three: The explanation for why things float that was mentioned above, does not say anything about density; it speaks only of pressure. Just how is density related to floating? One answer appeared quite often: ". . . objects less dense than water will float, and objects more dense than water . . ." Examples of more original and colorful explanations appear below.

Density is how close the molecules are. If they are far apart, the density is low because there is air between the molecules, and air is light. Thus the object floats.

The object will displace the amount of water which is equal to its volume, weight, or density.

Objects will float in water where the molecules are dense, but in water with less density they will sink. A good example is with sudsy water and tap water. Soap breaks up the water molecules, consequently, water molecules are less dense and objects sink.

Density is mass per unit volume. The denser an object is, the heavier it will be, the more water it will displace and the more prone it is to sink.

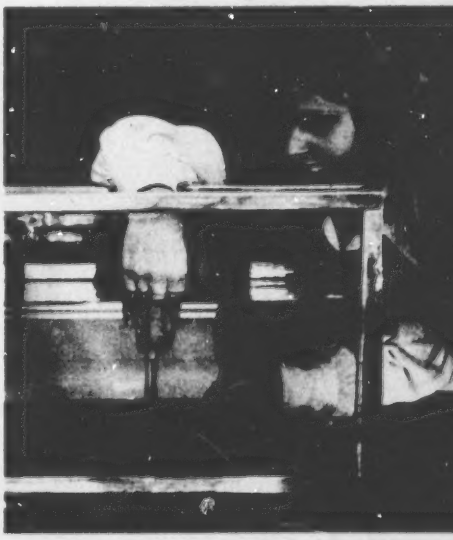

Figure 5. How much sand should be put into test tube so it doesn't sink or float, but merely "hovers" midway between the top and the bottom?

Because this was a homework assignment and students could consult with their peers, it is difficult to assess how many questions were answered incorrectly. This year, the same problems will be posed on a pre/post test basis in an attempt to measure gains from the unit, Clay Boats. It is hoped that some students can be interviewed on tape at the beginning and end of the activity. If other participating teachers in Clay Boat II would also administer pre post tests using these questions, and file their reports with this office, a great amount of data concerning cognition in students at various academic levels could be studied.

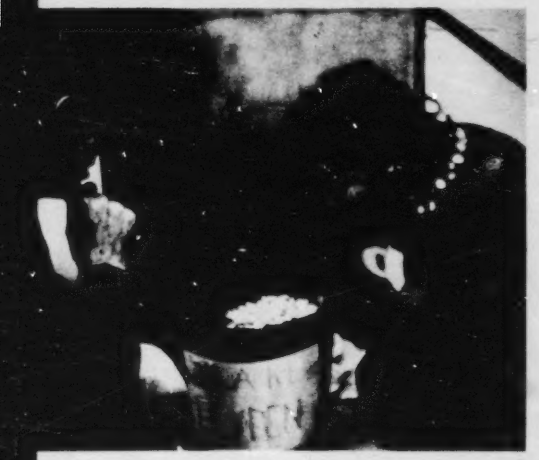

Figure 6. Students test hypothesis that boats float easier in a large body of water.

Figure 7. Clay and aluminum foil have same area. Which boat will hold more chips? How many more? And why?

Mental vortexes

Subtly whirling in this tranquil sea of clay is a myriad of questions which precipitate a variety of student behavior. Ronald Good stated that teachers are usually so preoccupied with the act of talking to children that they seldom ever listen to the thoughts of the child.[4] By proposing some of the activities below, and then stepping back and listening, teachers can gain a tremendous insight into student reasoning.

Seen in Figure 5 is a student who is trying to get a test tube filled with sand to achieve neutral buoyancy. Although this term was not used, the students were given a test tube, sand, and a cork. They were asked to put enough sand in the tube so that the corked vessel would not float on the surface or sink to the bottom, but would simply "hover" midway in the aquarium. This activity is related to question two of the aforementioned homework assignment. Even when the tube is barely floating, the addition of the tiniest sand grain can send it to the bottom amid student awe. Students have also noticed that in a similar situation compression of the cork in the tube will cause a similar reaction. This is certainly an activity where students are bobbing on the threshold of the true meaning of the word density.

Other activities provide the opportunity for the teacher to model the message of inquiry: probing with questions, listening to student commentary, agitating with phoney hypotheses to see if the student obediently believes the statement or challenges it. A prime example of the latter teacher behavior often occurs when students have trouble getting many chips in their boat. Teacher: "The reason that boat isn't holding much weight is due to the fact that you don't have enough water in your tray. The more water there is, the more pressure results, and it is the pressure that keeps the boat up. Right? Why don't you fill the wastebasket with water and you will see that the boat floats easier." Some students quickly accept the hypothesis and fill the wastebasket. Others balk at the idea. One student has actually "proved" the statement to be true. Her boat did float with greater cargo when placed in the "lake." See Figure 6.

Boats made from aluminum foil make an interesting contrast to those with plasticine hulls. Which boat holds more weight? The coed in Figure 7 cut her clay and aluminum so that their areas were equal. Another student tried to get the area and weight of each material to be equivalent. This was an interesting task.

Teacher: "Judy has 200 grams of clay and Darla has 100 grams of clay. This means that Judy's boat should hold twice as much weight as Darla's craft, right?" Such a hypothesis finds students pretty equally divided as to its truthfulness. Many other channels for student exploration are opened by such questions as: "What would happen to your clay boat if you fired it in a kiln?" "Someone make a milk carton boat." "Can you sink a wooden boat by putting in wooden cargo?" "Is there a minimum amount of water you need to get your boat to float?" "If you used water as the freight, how much would be needed to sink the boat?" This last question has the potential to lead students to a very important discovery concerning the maximum cargo their boat will hold.

Implications of the study

McKinnon's data plus the observations of others in combination with the author's experience in talking with boat-making college students provides for an incredible indictment against the current approaches by which science classes are conducted.[5] These methods seem only to produce students who are permanently paved in concrete operations. While these students are quite capable of memorizing gobs of material, they are unable to process it in a rational manner. Such an educational experience makes them prime targets for future shock in the decades ahead.[6]

Probably the most ironic observation made from this study is exemplified by the behavior of non-conserving students, and concerns their apparent concept of a teacher's role. Many of these students are now employed throughout the state; employed to "teach" children. Unfortunately, their teaching is but a mirror of what they so often saw modeled during their 16 years of schooling: didatic exemplar. Thus, these teachers are now telling (i.e. "teaching") their elementary students about the wonderful conservation schemes of science. Having been saddled with such a trite definition of the phrase, "to teach," they are only producing more citizens like themselves: i.e., those who are able

(Continued on page 46)

CLAY BOAT CONTEST

(continued from page 14)

to rotely "learn" such abstractions as $E = Mc^2$, regarding the constancy of energy-matter, but at the same time unable to conserve a lump of clay.

Happiness is challenging colleges to a clay-boat contest, and winning your own contest. And sadness is the data reported in Figure 3. If our schools continue to graduate students who cannot successfully navigate their mental crafts into the port of formal operations, then when called upon as adults to make rational decisions regarding all topics of life, they will be sunk.

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WORKSHOP **J**

thinking through problems involving conservation abilities

The purpose of this workshop is to give you an opportunity to do tasks which involve conservation abilities. After this workshop, you should have an appreciation for the complexity of the conservation abilities.

Listed below are several examples which embody some aspect related to conservation abilities. Read each example, then answer for yourself, each of the accompanying questions. You may wish to discuss some of these with colleagues.

1. A bucket is floating in a bathtub. Which (if either) will cause the level of the water in the tub to rise more: placing a brick in the water or a brick in the bucket?

   What type(s) of conservation abilities must be utilized in order to solve this problem?

2. An elementary school student asked two friends, "*Which is heavier, a pound of lead or a pound of feathers?*" One friend laughed. The other responded, "*The lead because lead is heavier than feathers.*"

   Although this is not a simple conservation problem (e.g., S must understand *pound* as a unit of measure that remains constant and independent of the materials), in terms of what you know about conservation abilities, what could you say about each of the students who responded?

3. A man in a large swimming pool marks the level of the water on the side of his boat and on the side of the pool. He then tosses a heavy anchor out of the boat and into the pool. How does this action affect each of the marks he made?

   What type(s) of conservation abilities must be utilized in order to solve this problem?

4. BOY: Please cut this pizza into slices.
PIZZA MAN: Do you want six slices or eight slices? BOY: Make it six slices. I don't think I can eat eight slices of pizza.

At what developmental level of conservation abilities must a person be to appreciate the humor of this joke?

5. For each of the cartoons below, decide what developmental level best relates to an understanding of the humor.

SMIDGENS **-By Bob Cordray**

WELL, SMIDGE...I THINK I'VE FINALLY FOUND A JOB!
REALLY?
YEAH, BUT THERE'S ONE DRAWBACK! I'LL ONLY GET PAID EVERY TWO WEEKS.
HECK, YOU'RE LUCKY TO GET PAID EVERY TWO WEEKS! ONE WEEK'S PAY WON'T BUY ANYTHING!

B.C. **-By Johnny Hart**

I HAVE A FISHING QUESTION.
HOW COME 5% OF THE FISHERMEN CATCH 95% OF THE FISH?
BECAUSE 5% OF THE FISH ARE SMARTER THAN 95% OF THE FISHERMEN.

By permission of John Hart and Field Enterprises Inc.

ANDY CAPP **-By Reg Smythe**

RAT-A TAT-TAT!
YER CAN'T GET A WINK O' SLEEP F' FLIPPIN' COLLECTORS! MUST YOU AVE ACCOUNTS WITH SO MANY DIFFERENT STORES?!!
IT MAKES THE BILLS SO MUCH SMALLER, PET
WOULD YOU MIND REPEATIN' THAT...?

review of research

Some Research Related to Conservation Abilities

Prologue

It is difficult to identify a single or simple concept for conservation. Perceptual dimensions change from task to task, and the number of perceptual dimensions that must be considered varies. For example, conservation of length involves a maximum of two perceptual dimensions, while conservation of volume involves a minimum of three perceptual dimensions.

The only aspect that unites conservation problems is reversibility. Reversibility is made up of two cognitive operations. One of the operations pertains to objects (reversibility by negation-inversion) and the other pertains to relations among objects (reversibility by compensation-reciprocity). Since the negation-inversion operation can be applied to single objects of thought one at a time, it is a singular transformation. Since the compensation-reciprocity operation must consider objects of thought two at a time, three at a time, etc. in order to speak of relations among objects, it is a binary transformation.

Apparently the two cognitive operations of reversibility are distinct when a student is at the first-order level of cognitive development (concrete operational) but are thoroughly integrated at the second-order level (formal operational). This difference is significant because it divides the set of all possible conservations into two distinct subsets (Brainerd 1970). First-order conservations (number, length, height, solid amount, liquid amount, area, weight) are indexes of concrete operational thought. Second-order conservations (volume, density, displacement, momentum, rectilinear motion) are indexes of formal operational thought. They differ in that the former necessitate only the successive application of the two cognitive operations while the latter require the simultaneous and coordinated application of the two.

Log

All conservation tasks essentially build upon a triad of trials concerned with the same objects. Any common objects can be used to assess a conservation. For example, one might use keys and locks. In the first trial (a) the equivalence between keys and locks is established. In the second trial (b) the locks might be moved farther apart, the subject is questioned about equivalence of the two sets of objects, and he is asked to verify his answers. In the third trial (c) the locks are returned to their original positions.

(a) A = B
(b) A → A' or B → B'
(c) A ← A' or B ← B'

Another triad might be given with a variation at the second trial: (b) the locks are moved closer together. Other triad variations can transform the keys instead of the locks.

Piaget has not been interested in exploring the specific experimental variables that might develop conservation abilities. He has been more interested in understanding the concepts of conservation and in describing the development of the conservation phenomena. Experimental variables that are influential in development have been studied by other researchers.

All conservation research experiments begin with the division of subjects into conservers and nonconservers on the basis of a conservation pretest. The nonconservers are then divided into experimental and control groups for the experimental part of the study. A growing number of studies have primarily attempted to answer the following questions: Can conservations be taught? Do conservations generalize to new situations? Are some conservations more resistant to extinction than others?

Training Studies

A fairly large amount of research literature pertains to attempts to create the right conditions for the acquisition of a conservation. In this literature there are about as many unsuccessful attempts as there are successful attempts, and those that are successful are only partially so. So far, no experiment has given a satisfactory indication of how to bring about or control the acquisition of a conservation.

Number. Of all the conservation abilities, number has received the most experimental attention. The experiments have primarily focused upon attempts to train number conservation to nonconservers.

Wallach and Sprott (1964) were successful when they varied the spacing between objects in a row and coupled this with the addition and subtraction of objects. Gelman (1969) found that reinforcement of responses brought about the ability to conserve number. Beilin (1965) was successful when he enriched the subject's perceptual experience. Wallach et al. (1967) used both verbal and perceptual methods for instruction and found success.

About as many experimenters did not find success. Mermelstein and Meyer (1969) replicated four training methods used by other experimenters (Beilin 1965; Bruner 1964; Sigel, Roeper, and Hooper 1966; Smedslund 1961e) and found that none produced number conservation. Wohlwill and Lowe (1962) used three distinct training procedures: trial-by-trial with reinforced practice, practice in adding and subtracting objects in rows, and dissociation of a perceptual clue from number cues. They found that all procedures failed to develop number conservation.

Length. Experiments that have attempted to train for length conservation have produced mixed results.

Gelman's (1969) successful study is the most elaborately designed. She used six triads of sticks that varied in length, position, and color. Subjects were given discrimination trials with these properties so that they would attend to only the relevant cues. Gelman's training procedure specified reversibility by negation-inversion. For example, whenever a particular perceptual transformation was inherent in a given triad (one stick moved forward), the inverse of the transformation was inherent in a later triad (the stick returned to its starting point).

Beilin (1965), Gruen (1965), Kingsley and Hall (1967), and Murray (1968) used different training procedures, but all reported success in training for length conservation. Murray added and subtracted arrowheads on the lines. Beilin and Gruen specified the inverse of perceptual transformations. Kingsley and Hall used a learning set method along with the inverse of perceptual transformations.

The most noteworthy failure to train for length conservation was reported by Smedslund (1963), who used five separate training methods which did not specify operational reversibility.

Solid and Liquid Amounts. Again there is a balance between successful and unsuccessful studies. Only a few are reported here. Smedslund (1961e) was successful in training for solid amount conservation. Brison (1966) reported that it was possible to train liquid amount conservation. His training procedure used two identical glasses filled with equal amounts of water, and he included the inverse of each transformation.

Fleischmann et al. (1966), Frank (reported in Bruner 1966) and Sonstroem (1966) all reported a lack of success.

A relationship between students' oral sentence structures and conservation of solid amount was noted by Sinclair-de-Zwart (1967). Students at the preoperational level spoke

about the differences after a transformation in short sentences, such as, "*This one is long. This one is short.*" Students who had operationally mastered the conservation described more than one structural difference in a complex statement about an object, "*This one is longer and thinner than the other one.*"

Weight. More studies report failure to train for weight conservation than report success.

Smedslund (1961b, 1961d) failed to train for weight conservation. Brison (1966), Sullivan (1967), Hall and Kingsley (1968), and Hall and Simpson (1968), using similar training techniques, failed to train for weight conservation.

Kingsley and Hall (1967) and Smith (1968), using different methods, also reported a lack of success. Smith presented subjects with pairs of identical clay objects, one of which was subsequently deformed, and asked whether or not the two continued to weigh the same. Kingsley and Hall used the inverse of transformations in their training trials.

Strauss and Liberman (1973) found that when provided with empirical evidence of nonconservation of weight, concrete operational level students did not accept the evidence. The authors interpreted their results as being supportive of the developmental claim that lower levels of reasoning are transformed into structurally more advanced levels.

It seems clear that students who are preoperational cannot conserve when provided weight conservation tasks and those who are concrete operational can conserve only after they have constructed the concept of mass conservation. However, Dasen and Christie (1972) report that there is an apparent "regression" phenomenon among these latter students at approximately ages 10 to 11, and Miller (1973) found that even college students tended to accept evidence of nonconservation of weight while providing sophisticated justifications to explain their acceptance.

It is interesting to find that in the history of science, weight's complex relation to both mass and matter made it difficult for scientists to differentiate between them (Meyerson (1907).

Other Conservation Abilities. There is no research indicating success in the training of the other conservation abilities. It should be noted, however, that Piaget's reversibility by negation-inversion is implicit in each of the successful training methods and that it is missing in the unsuccessful ones. The studies presented here also indicate that age is not related to success or failure in the training of a conservation ability.

Transfer Studies

An important research question has to do with whether or not a student will continue to conserve a particular invariant property when confronted with stimuli other than those on which he was trained.

Evidence supporting transfer to closely related situations (specific transfer) has been found by several researchers. Wallach and Sprott (1964) Beilin (1965), Murray (1968), and Gelman (1969), in differently designed studies, were able to train for number conservation and found transfer of this ability to novel materials. There have been no reports of failure to find specific transfer. Brison (1966) found there could be specific transfer of liquid amount conservation that had been acquired through training. No studies have examined the specific transfer of other conservations.

Another important research question has asked whether or not a student will be able to transfer and conserve on dissimilar conservation abilities for which there has been no training.

Such nonspecific transfer studies have consistently met with failure. Mermelstein and Meyer (1969) found that solid and liquid amount conservations were not facilitated by the ability to conserve number. After training their subjects in number conservation, Wallach et al. (1967) found no transfer to substance conservation or area conservation; Beilin (1965) found

no transfer to area conservation; and Gruen (1965) found no transfer to either length, solid amount, or liquid amount conservations. Kingsley and Hall (1967) and Murray (1968) found no transfer of length to conservation of solid amount, liquid amount, or area. To date there have been no adequately administered studies that examine nonspecific transfer from the other conservations.

In summary, there have been no studies that have reported a failure to find specific transfer and no studies that have reported a success in finding nonspecific transfer.

Extinction Studies

Extinction studies utilize a procedure that artificially violates the subject's expectations of a conservation. To accomplish this, the experimenter allows the subject to make a correct prediction, but before the subject can verify his prediction, the experimenter covertly alters one of the stimuli so that the invariant property is not conserved.

Wallach and Sprott (1964) reported that it was difficult to extinguish number conservation in both natural and trained conservers.

Brison's (1966) extinction study utilized a glass with a false bottom. When identical amounts were poured into two glasses, the false bottom in one made the liquid in that glass appear greater. Brison found that the concept of conservation of liquid amount was highly resistant to extinction in both natural and trained conservers. He also found there was no difference in the rates of extinction between natural and trained conservers.

In conservation of weight extinction experiments, Kingsley and Hall (1967) and Smith (1968) reported similar findings. They found that the concept could be extinguished for both natural and trained conservers. They also found that natural and trained conservers did not extinguish at different rates. Smedslund (1961c) also found that conservation of weight was easy to extinguish but that trained conservers extinguished more readily than natural conservers.

These findings indicate that weight conservation is not very resistant to extinction as compared with number, solid amount, and liquid amount conservations.

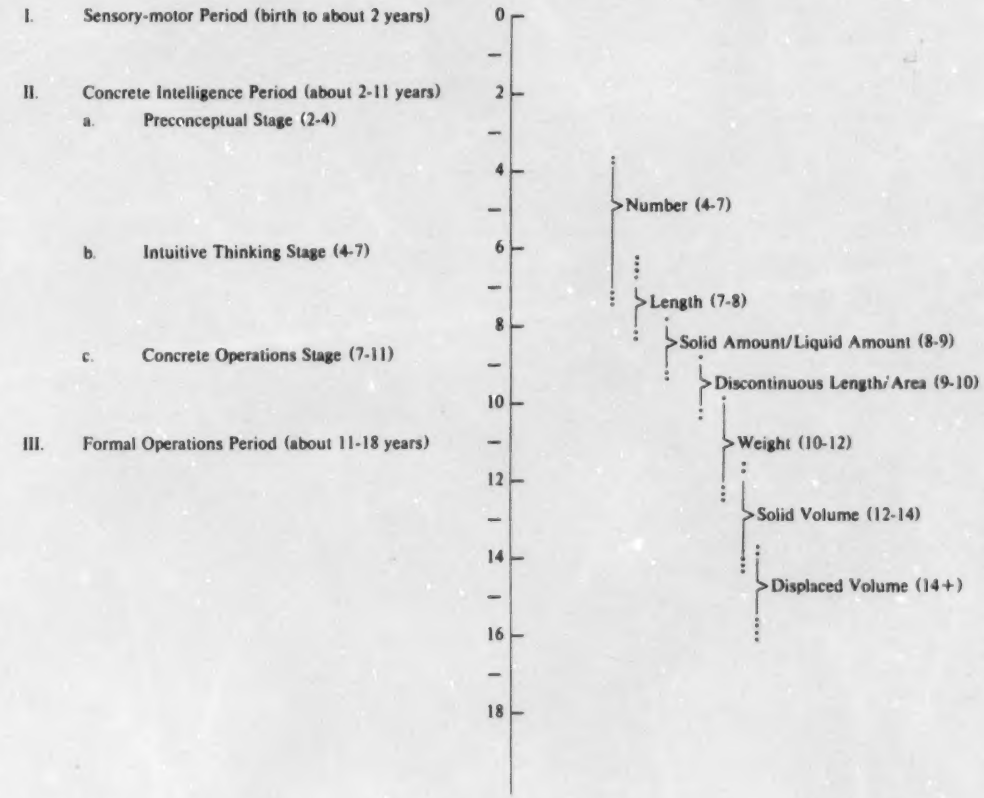
Epilogue

Research related to conservation abilities has not provided much usable information to date. Piaget has indicated that it is pointless to spend time on the intensive, specific training of conservation abilities because such learning will not last, will have limited generalizability, and will be unlikely to have a general effect on the level of understanding. He insists that the student must take an active part in making the transition. For teachers, it seems that experiences related to conservations (e.g., counting relates to conservation of number; weighing relates to conservation of weight) are more valuable for students' development than is that direct instruction of conservations. Support for this view is provided by psychologist Robert Gagńe, who warns that recent studies in development with students bear out the thesis that the growth of concepts and logical thinking is related to a great deal more than the mere practice of procedures.

PIAGET'S DEVELOPMENTAL SEQUENCE

LOWERY'S STRAND

Periods of Development	Ages*	Conservation Abilities



*All ages listed on this page are approximations

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appendix

Understanding Relational Terms Checksheet

Student	Terms								
	same	different	more	less	higher	lower	other terms		

Understanding Relational Terms Checksheet

Student	Terms								
	same	different	more	less	higher	lower	other terms		

Understanding Relational Terms Checksheet

Student	Terms								
	same	different	more	less	higher	lower	other terms		

Understanding Relational Terms Checksheet

Student	Terms								
	same	different	more	less	higher	lower	other terms		

Record of Conservation Tasks

Student's Name:_____ Age_____

Administered by:_____

Task	Student's Responses	P	T	C	Administrator's Comments	Date
Number						
Continuous Length						
Solid Amount						
Liquid Amount						
Discontinuous Length						
Area						
Weight						
Solid Volume						
Displaced Volume						

P = Pre-conservation
T = Transition
C = Able to Conserve

Record of Conservation Tasks

Student's Name:_____ Age_____

Administered by:_____

Task	Student's Responses	P	T	C	Administrator's Comments	Date
Number						
Continuous Length						
Solid Amount						
Liquid Amount						
Discontinuous Length						
Area						
Weight						
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